Presentation at the First Plenary Meeting of the Advisory Committee on Acoustic Impacts on Marine Mammals

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Acoustic Methods Used In Research

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1. What activities produce sound; how is it produced; for what purpose?

2. What are the characteristics of sound produced?

3. What issues are most in need of attention currently? In the future?

What research activities produce sound?

Ocean research makes use of sound in three different ways:

A. Propagation studies -

Transmit from one point, listen at another

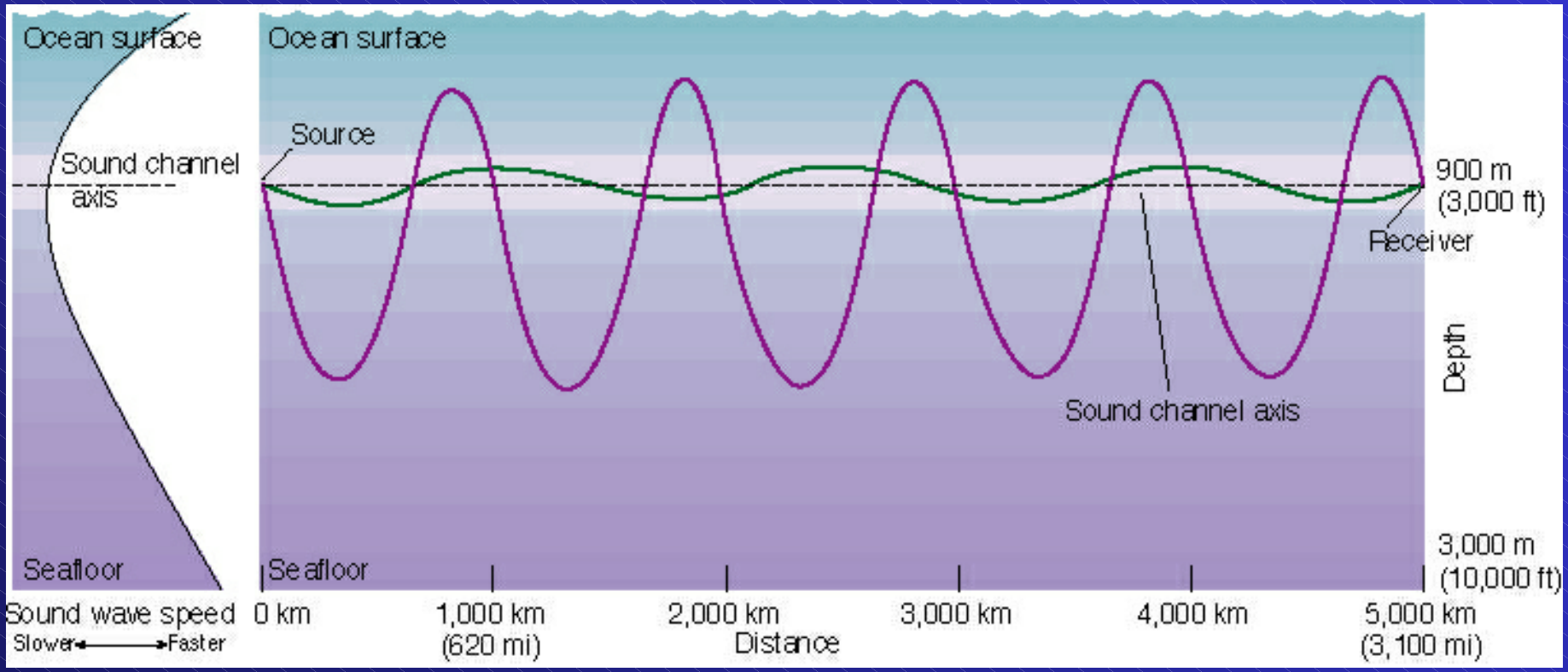
B. Back scatter sonar -

Transmit at one point, listen to reflected signal at same point

[C. Passive detection -

Interpreting the naturally occurring sound in the ocean]

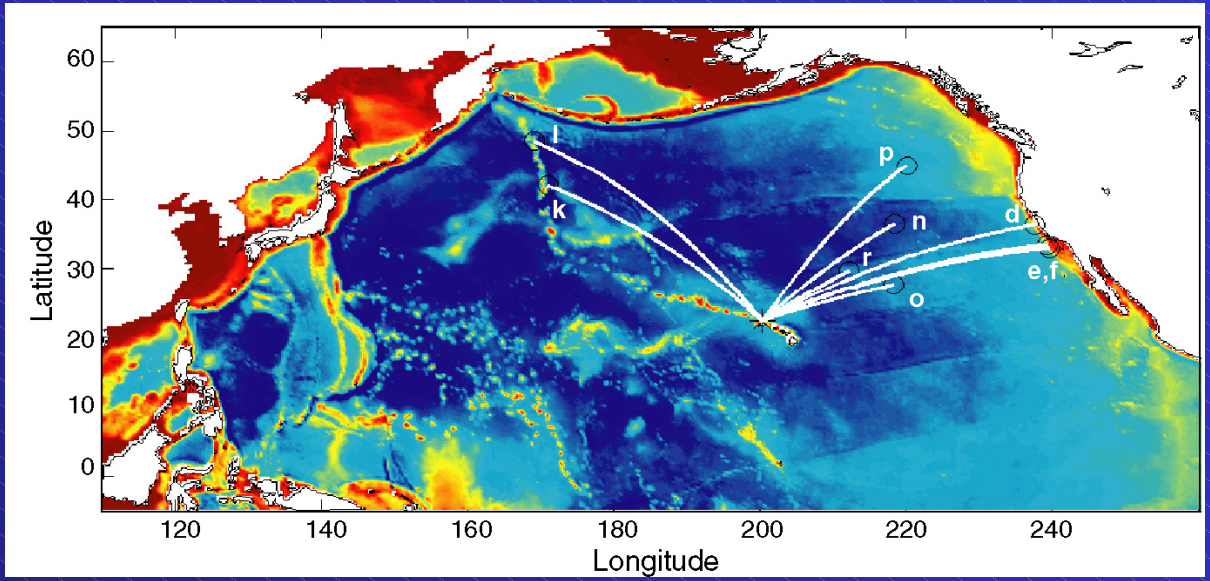
A. Propagation -



The ocean modifies the sound traveling through it, affecting its speed, intensity, arrival pattern, etc. Analysis of the resulting signals provides a basis for learning about ocean properties.

SIO

For what purpose?



To address fundamental questions about the earth's climate and its prediction:

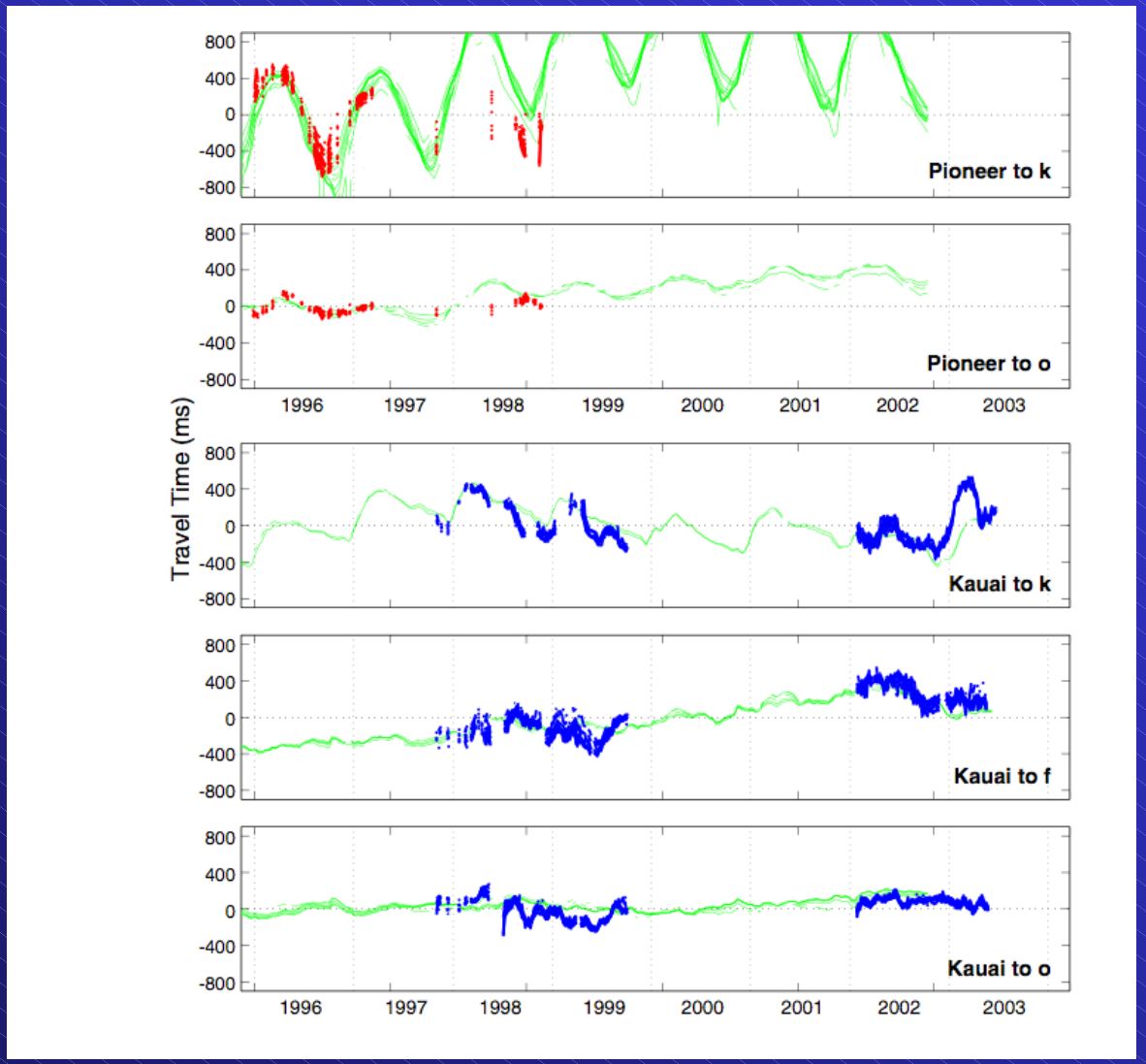
How is heat distributed in the ocean?

How is the heat content and distribution changing?

How do we constrain planetary climate models towards meaningful results?

Present studies are exploring the feasibility of long range measurement for this purpose.

Acoustic thermometry can constrain ocean circulation and climate models by providing integrated temperatures averaged over 1000s of km.



P Worcester

A. Propagation studies - How is the sound produced?

Sound is typically generated by cabled piezo-electrically driven sources:

Sound source used for long range propagation in ocean climate studies

Great range can be achieved at relatively low power by using long, coded signals that are recombined upon reception to achieve the equivalent of a short, much louder source and by making use of the ocean sound channel.

A. Propagation studies -

Source characteristics for Ocean Climate research

SOURCE LEVEL = 195 dB re 1 microPa at 1 m

CENTER FREQUENCY = 75 Hz

BANDWIDTH = 37.5 Hz (Q = 2)

PULSE REPETITION RATE (TYPICAL) = Six 20-minute transmissions at 4-hour intervals on every fourth day (2% duty cycle)

APPROXIMATE RANGE TO 180 DB RECEIVED LEVEL: 5.6 m (assumes spherical spreading)

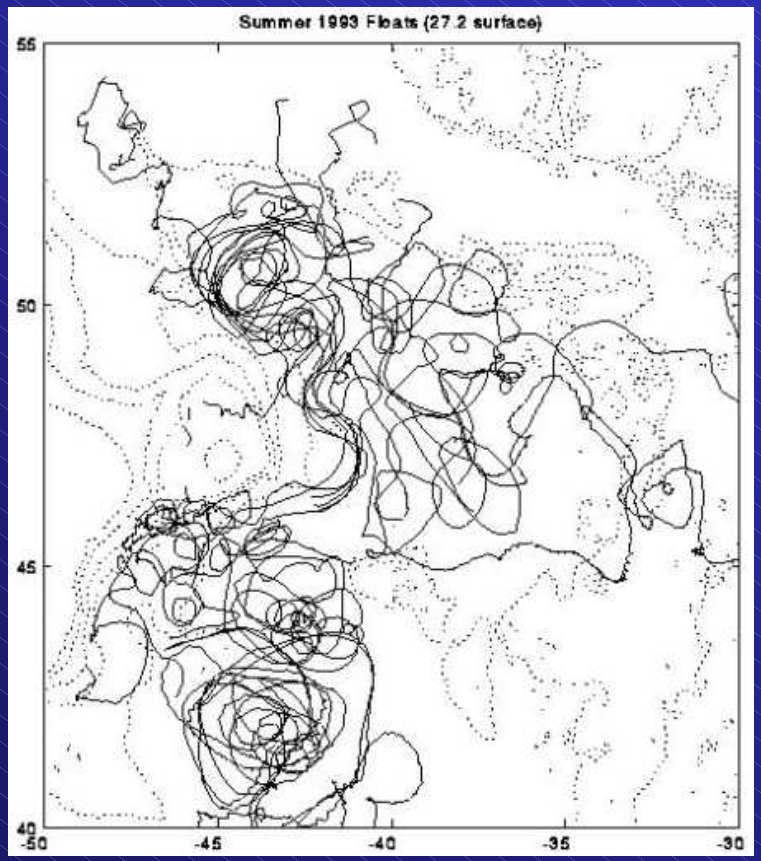
A different application: Determining positions of neutrally buoyant floats

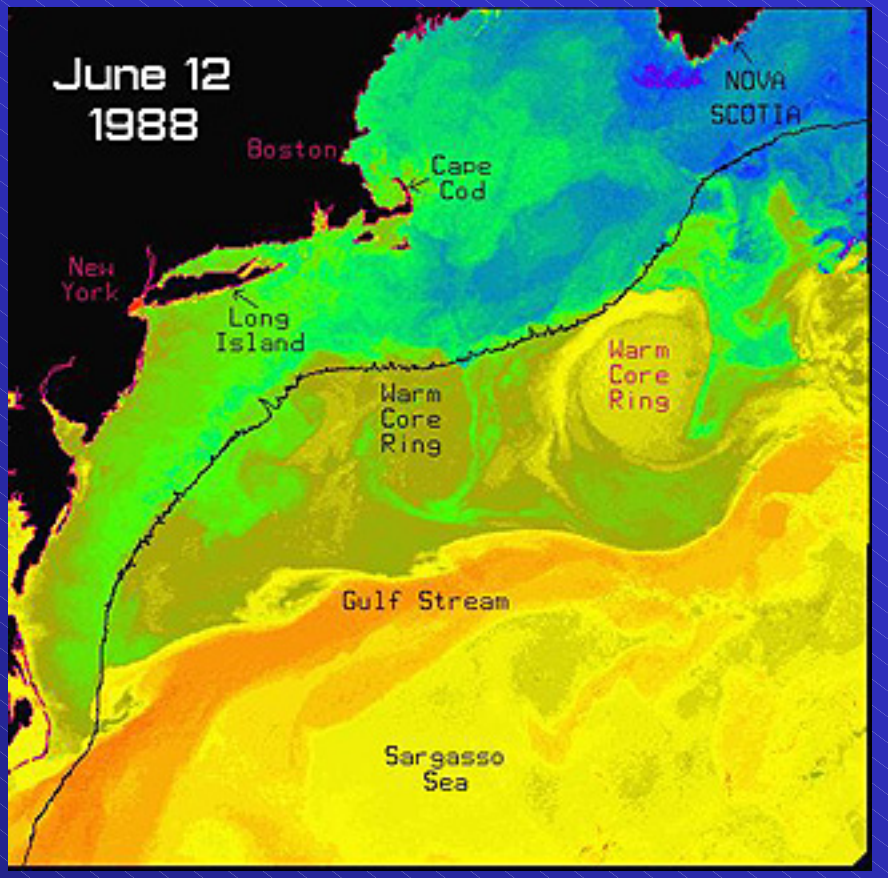
Source characteristics: 80s long FM ‘chirp’, 259.375 - 260.898,

Power level; 170 - 184 dB re 1 μPa at 1 m.

Battery powered system.

For what purpose?

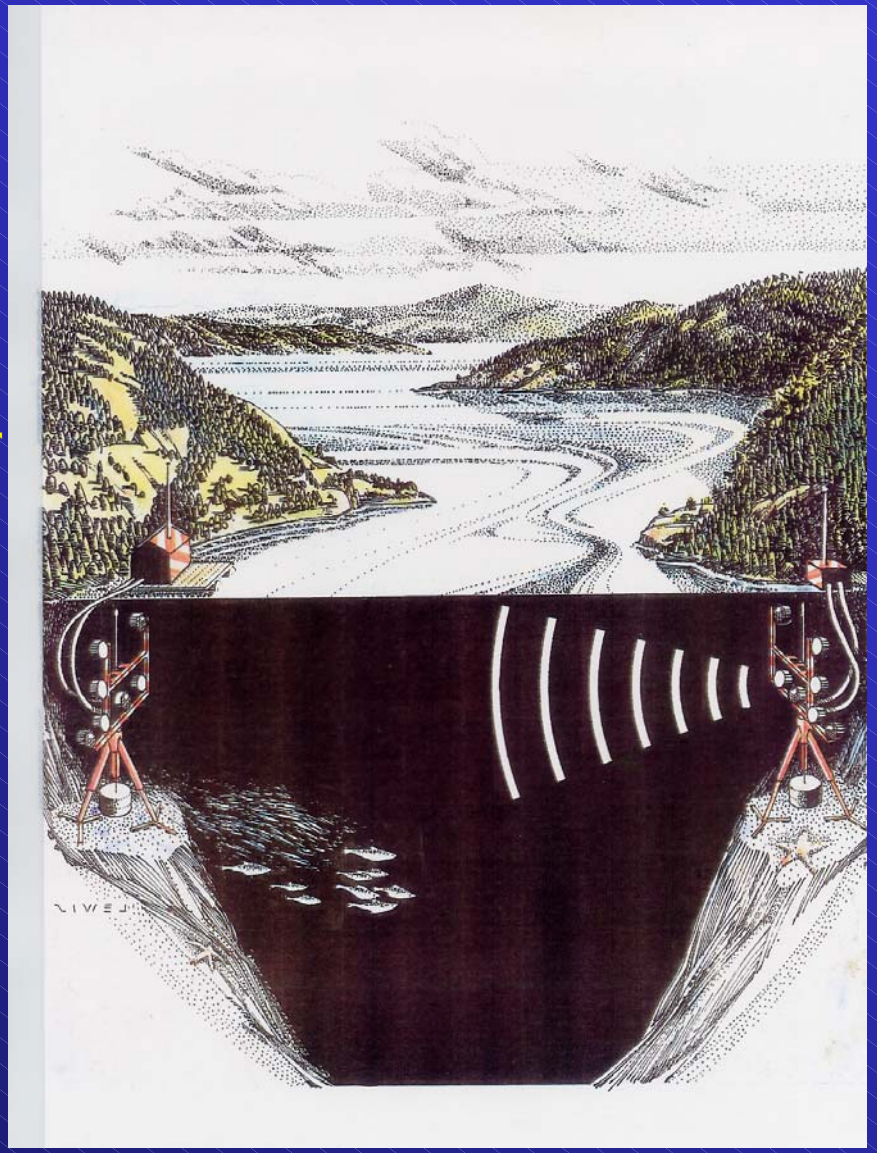




Neutrally buoyant floats drift with the deep ocean currents, providing unparallelled records of ocean dynamics and properties. They position themselves by listening to transmissions from moored sources.

A. Propagation - small scale studies

A wide variety of small scale sources are used for propagation measurements, tracking and navigation in the coastal environment. These systems cover a very wide range of frequency, source characteristics and power levels, but typically operate at higher frequencies and much lower power levels than the long range systems described earlier.



B. Back-scatter acoustics - Seismic Studies

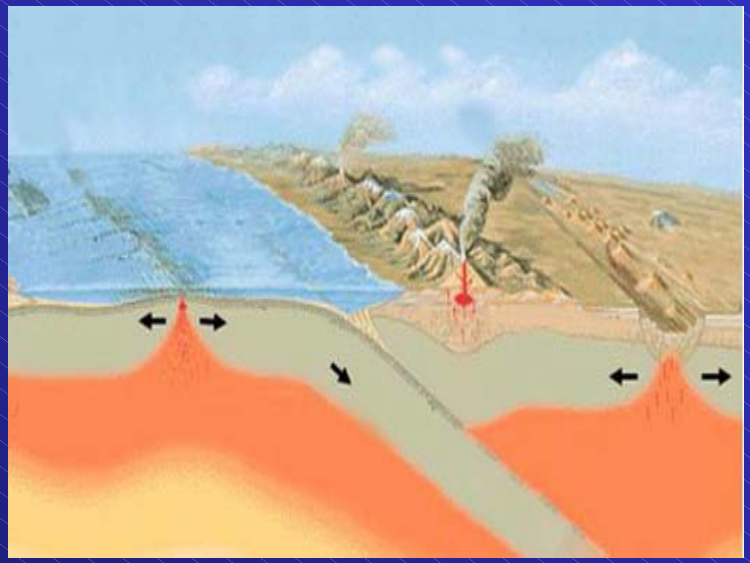
Seismis Studies: For what purpose?

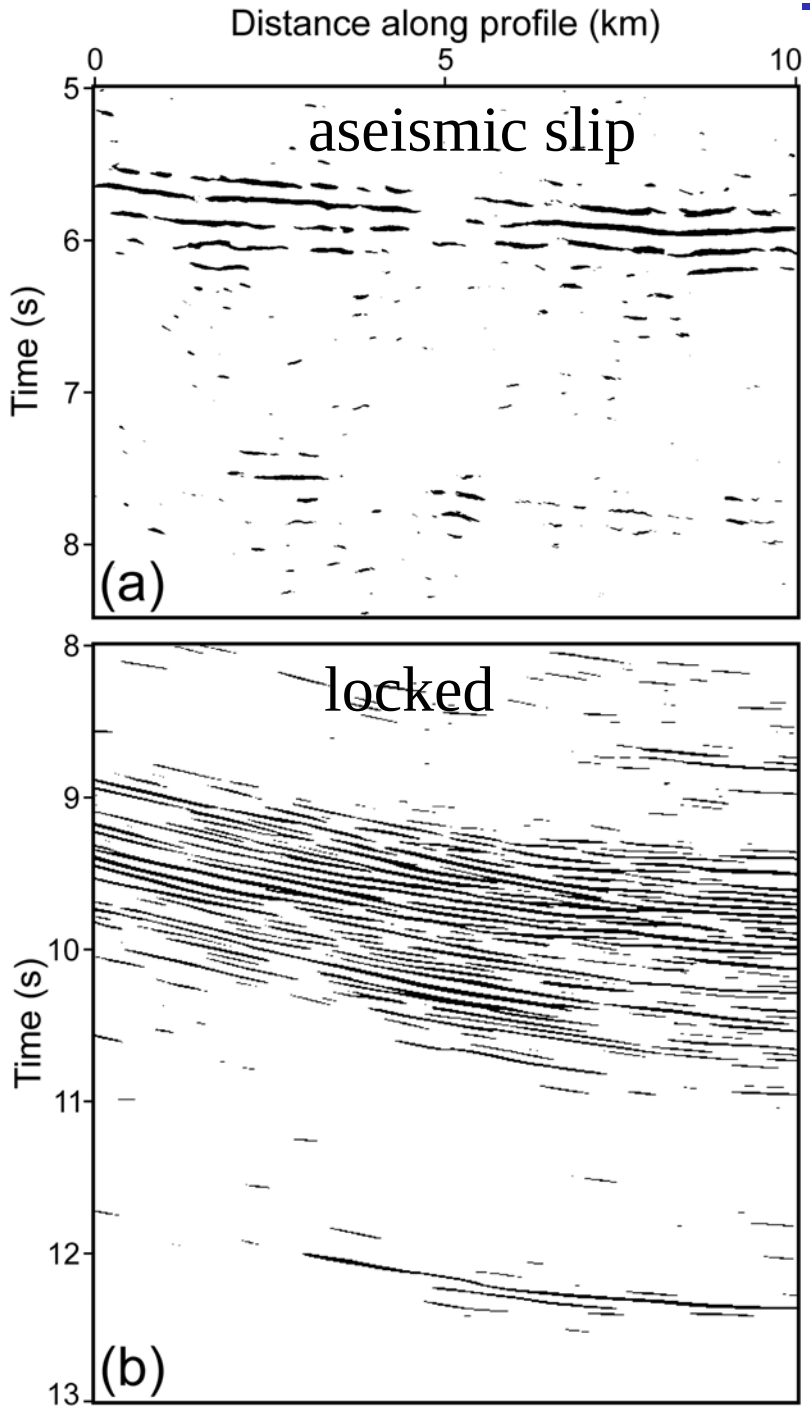
To address fundamental questions about the sea-floor, its evolution and impact on life.

Examples

1. Earthquake studies

Can we understand the seismic processes in subduction zones well enough to predict these dangerous events?




Distance along profile (km)
0
5
10
aseismic slip
Time (s)
5
6
7
8
(a)
locked
8
9
10
11
12
13
Time (s)
(b)

<2 km
Thin thrust reflections
Subducted oceanic crust
Oceanic Moho reflections
>4 km
Wide reflection band
Subducted oceanic crust
Oceanic Moho reflections

Seismic Studies: For what purpose?

To address fundamental questions about the sea-floor, its evolution and impact on life.

Examples

2. Gas hydrates

Carbon in gas hydrates is at least twice the amount of carbon held in all other fossil fuels on earth (possible future energy source)

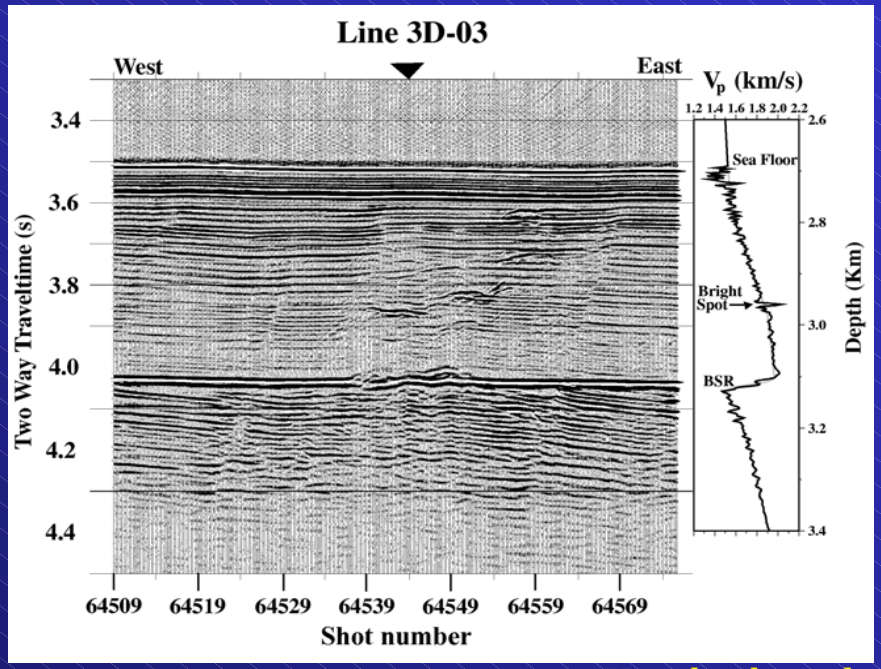
Seismic Studies: For what purpose?

To address fundamental questions about the sea-floor, its evolution and impact on life.

Examples

2. Gas hydrates

Methane is a powerful greenhouse gas, entrapped in hydrates by pressure and low temperature.



Hornbach et al.

Seismic Studies: For what purpose?

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Examples

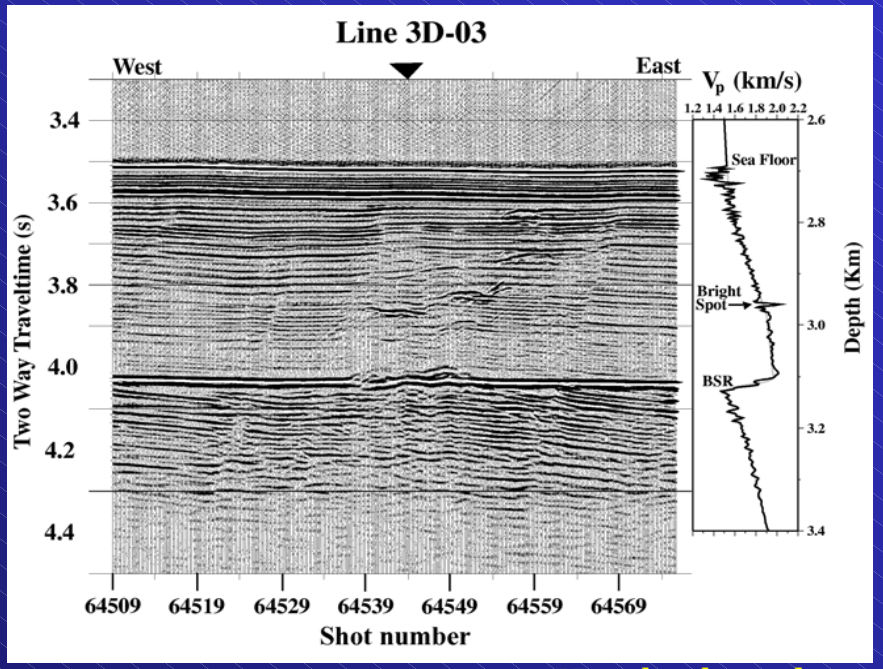
2. Gas hydrates

Methane is a powerful greenhouse gas [GHG], entrapped in hydrates by pressure and low temperature.

Its release may be accompanied by

slides / tsunamis

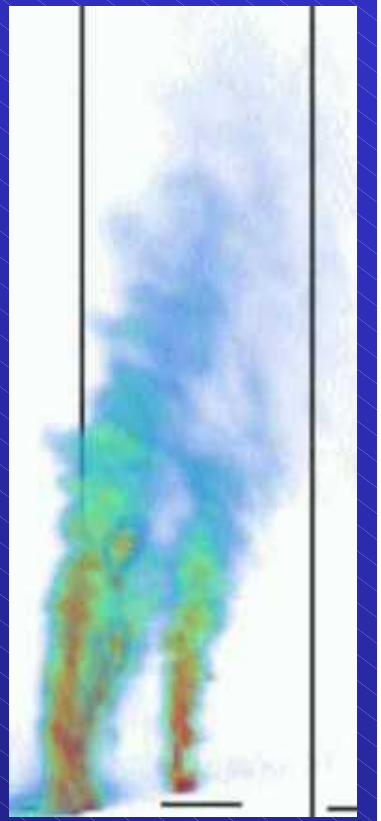
build-up of GHG in atmosphere



Hornbach et al.

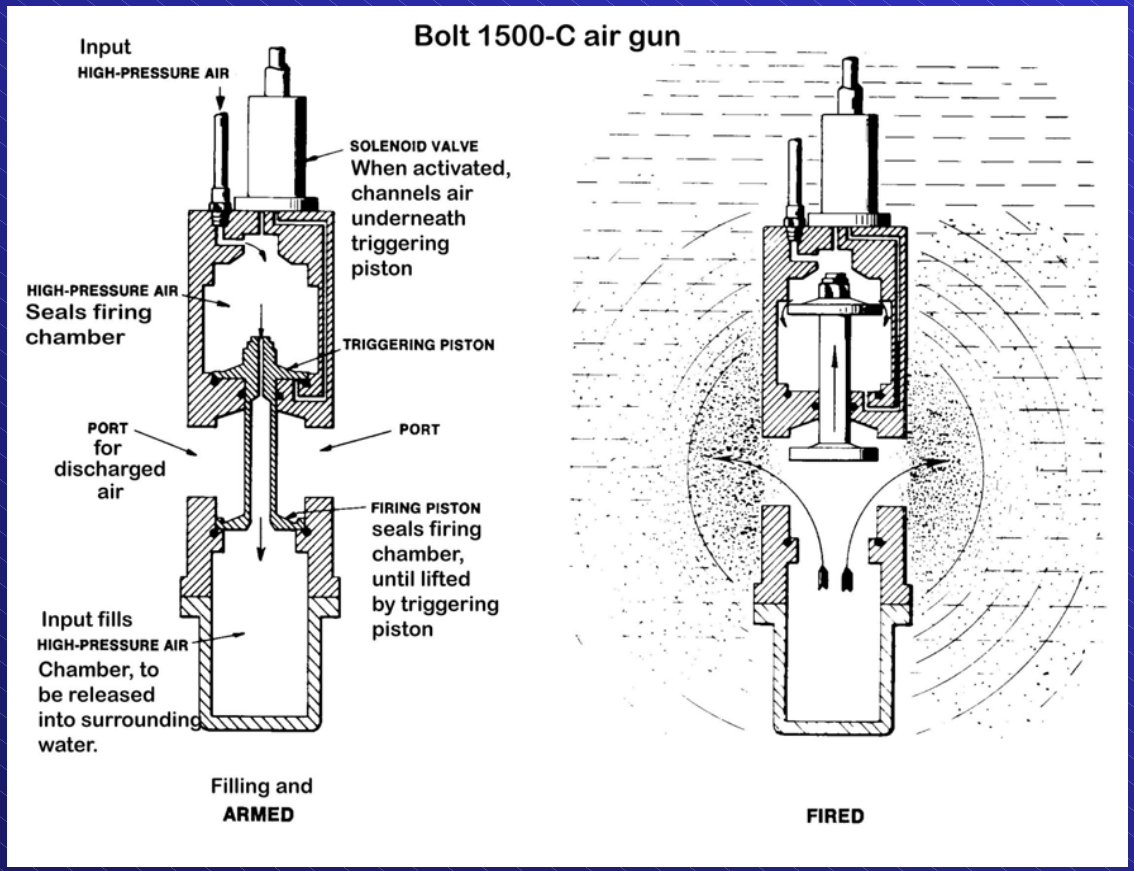
Seismic Studies: For what purpose?

Seismic studies are vital to understanding exchanges between the ocean and sea floor environment, including hot vents and their astonishing life forms that may be linked to the origin of life on our planet.



B. Seismic Studies - How is the sound produced?

For seismic research sound is typically generated by a towed array of air-guns



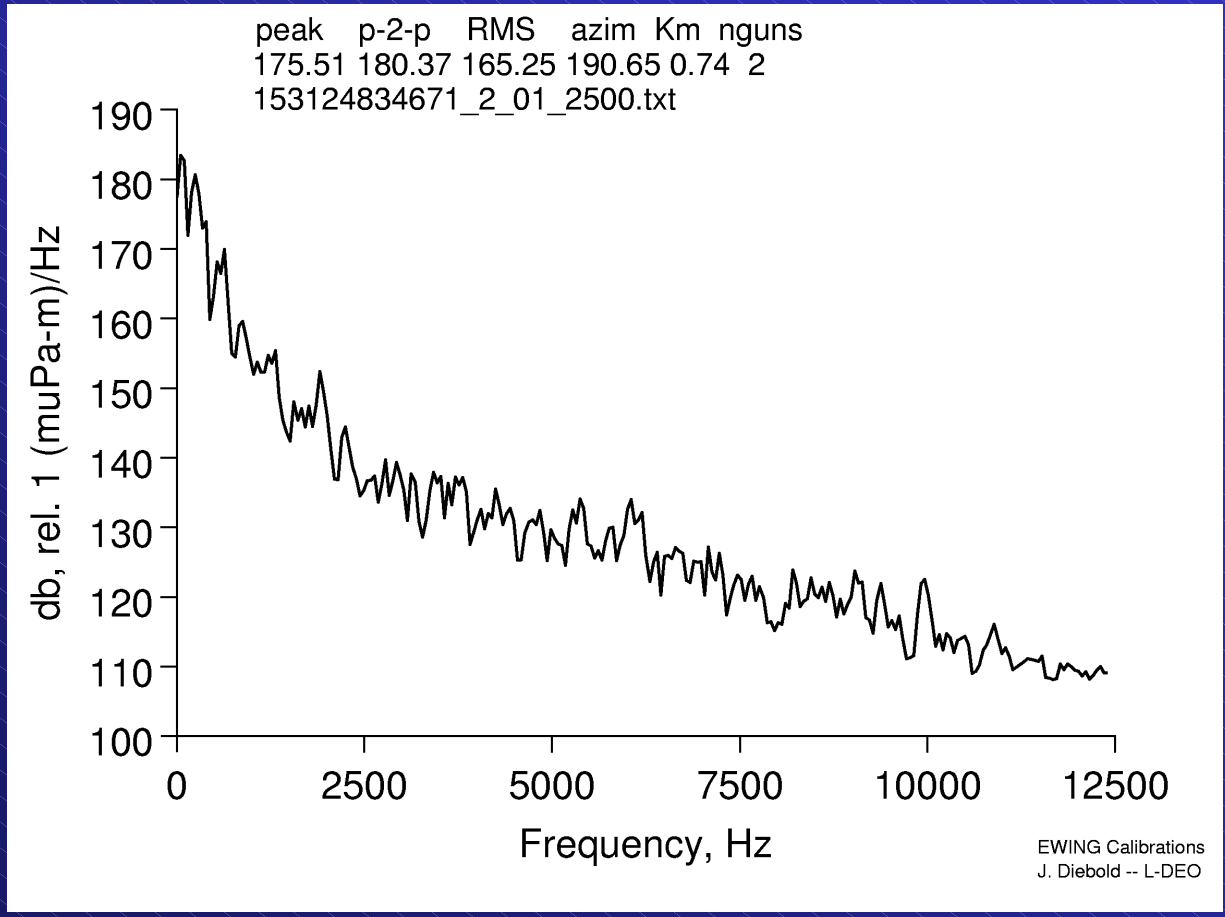
Schematic diagram of air-gun

Source characteristics

The transmissions are from a distributed array, so a “point source level” is virtual representation, useful for far-field calculations, not directly representative of source levels at the array. For the air-gun array, maximum sound pressure levels are 220dB re 1 μPa at 1m, although the corresponding “point source level” can be 40 dB greater.

Source level spectrum.

Note: most of energy is at 0 - 100Hz. Levels are 40 - 50 dB lower at 3.5 kHz

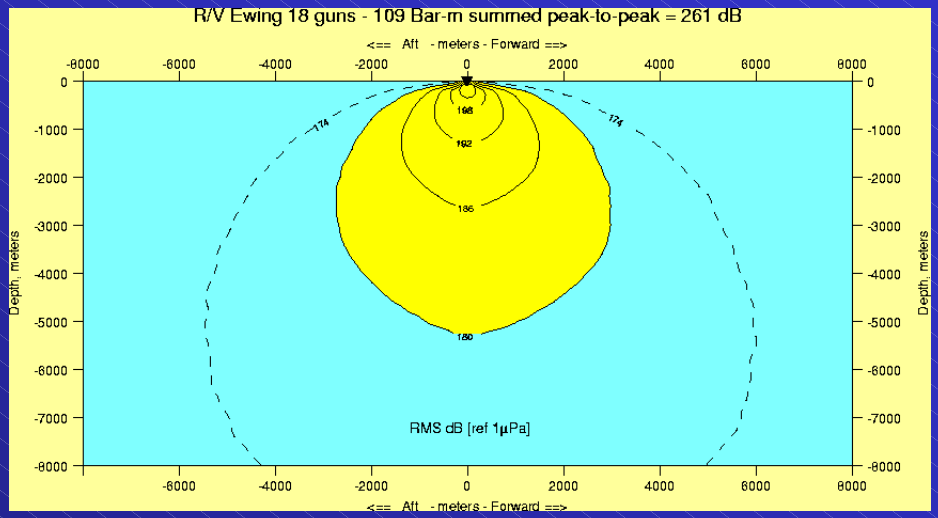


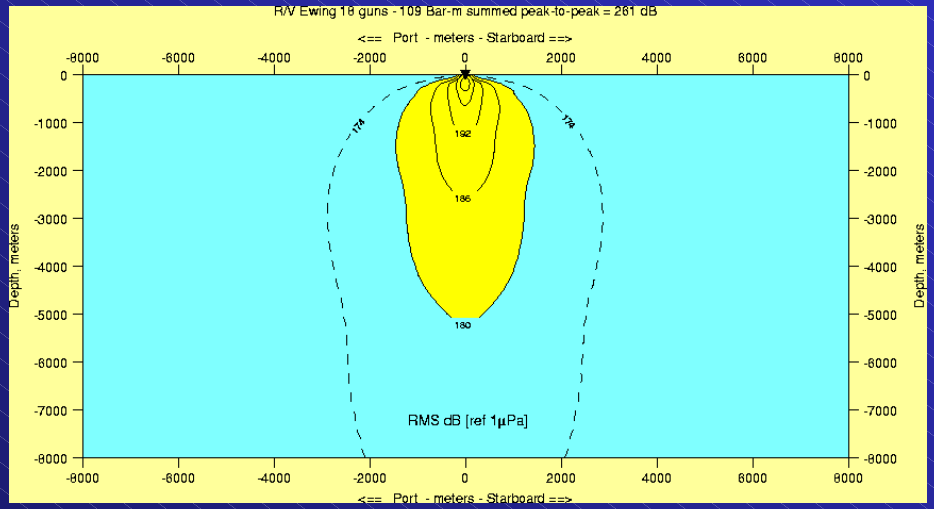
Ramp-up time: 25 minutes for 20 gun array

The Safety Radius

Safety radius corresponding to the 180 dB isopleth.

The radius for mammals which do not dive deeply may be much smaller than the maximum.





B. Back scatter sonar -

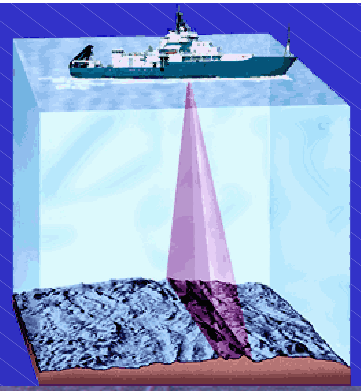
Transmit at one location, listen to reflected signal at same location

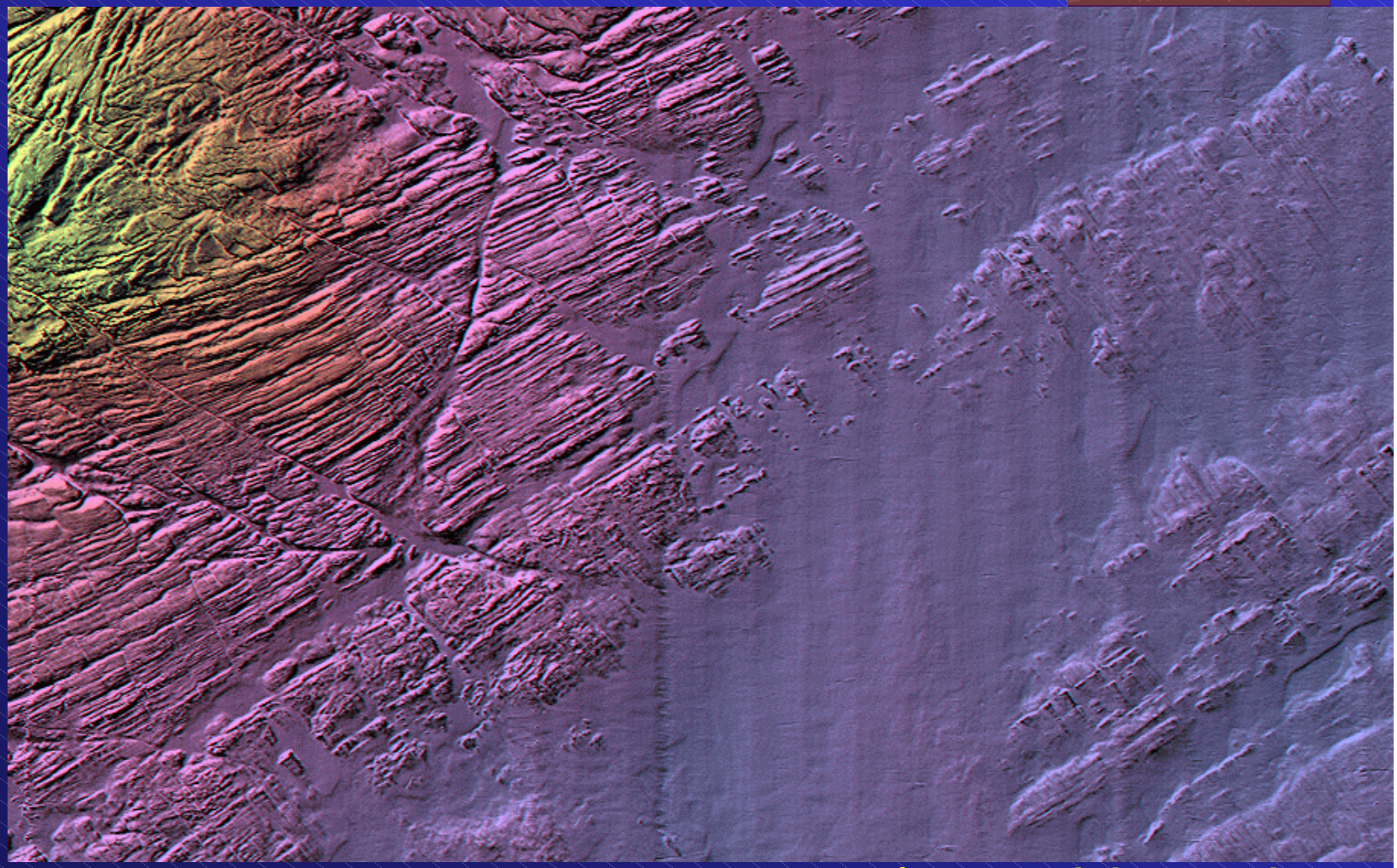
Examples:

- Depth sounders
- Fish detection sonars
- Navigational, bottom detection sonars
- Bathymetric mapping sonars
- Doppler sonars
- Seismic towed arrays

Deployed on ships, moorings, autonomous underwater vehicles, etc.

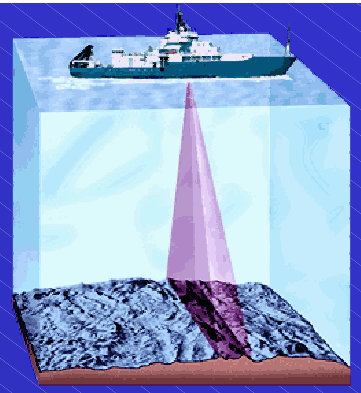
Multibeam, bathymetric sonar





Near site of SwissAir Flight 111 crash site

For what purpose?



Preparation of navigational charts

Seafloor resource mapping

Research on marine geology

Searching for lost ships and aircraft, etc.

Sample multibeam sonar properties

SeaBeam Dual Frequency 1050D

Frequency:	**50 kHz**	**180 kHz**
Number of Beams:	126 (fewer selectable)	126 (fewer selectable)
Beam Width:	153°	153°
Max. Pulse Power:	3,5 KW per transducer array	500 W per transducer array
Max. Source Level:	234 dB 1 µPa/1 m	220 dB 1 µPa/1 m
Pulse Length:	0.3, 1, 3, 10 ms; selectable	0.15, 0.3, 1.3 ms; selectable
Bandwidth:	12 kHz, 3.3 kHz, 1 kHz; selectable	12 kHz, 3 Hz, 1 kHz selectable
Sidelobe Suppression:	36 dB (transmission and reception)	36 dB (transmission and reception)
Repetition Rate:		

Seabeam 2112

12 kHz
121
120°
234 **dB** re 1 µPa @ 1m
3-20 ms
2 - 20 s

B. Research in fisheries & biological oceanography

In addition to standard commercial fisheries sonars used by the fishing industry, a wide range of specialized sonars are being developed, including underwater acoustic cameras, intermediate range imaging sonars, etc.

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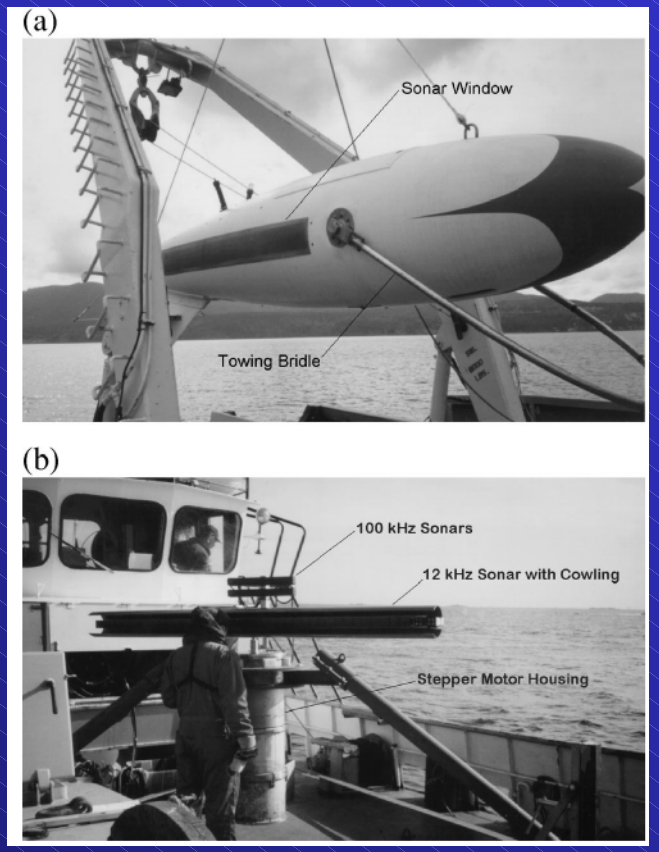

Intermediate range fisheries sonar:
(a) Towed
(b) Bottom mounted

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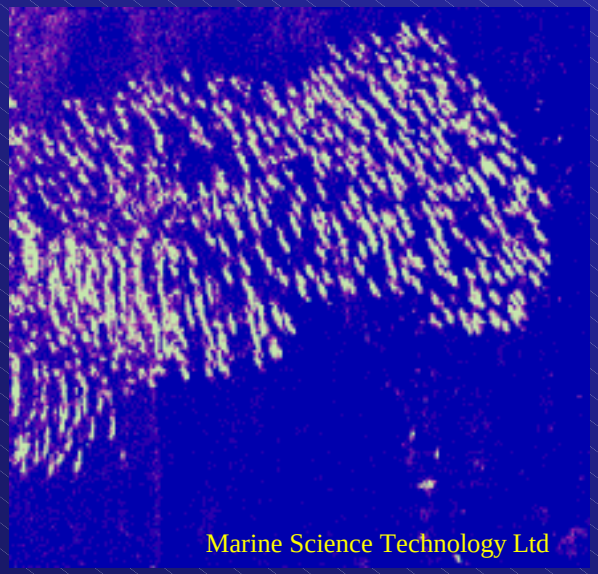
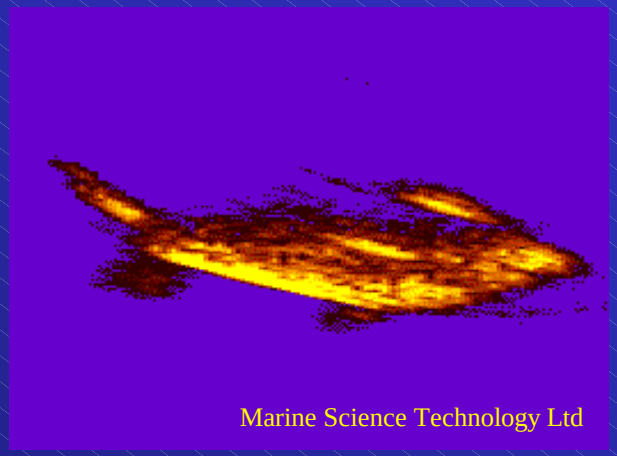
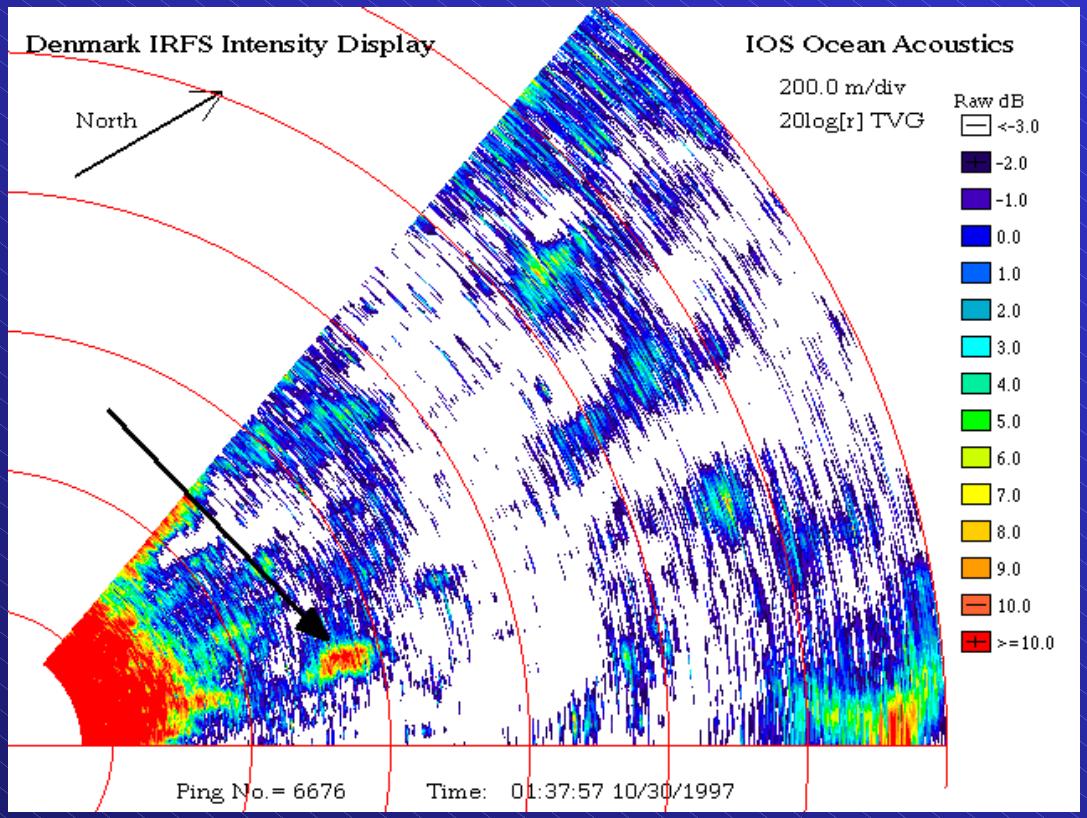




For what purpose?

Fisheries ecology studies

Abundance of different species, schooling behavior, response to environmental stress, etc.



Source characteristics

Example: Intermediate Fisheries Sonar

Frequency: 12 kHz

Source level 216 dB re 1 μPa at 1m

Pulse form: 1600 Hz x 0.2 s linear FM sweep

Pulse duration: 200 ms

Typical towing depth 35 m

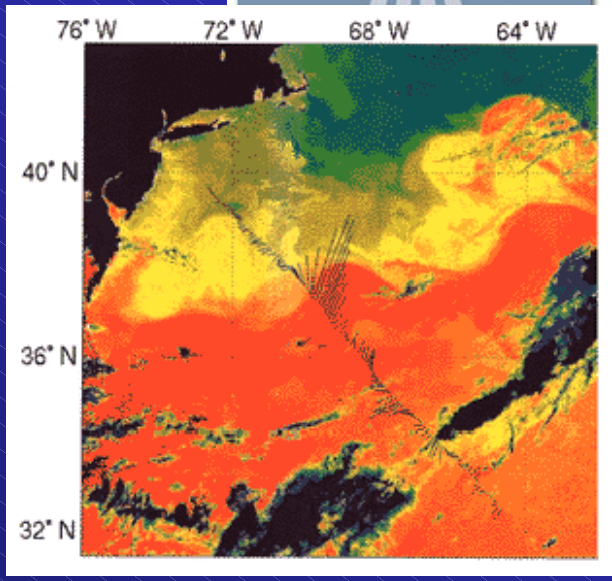
Beam angle (horizontally oriented): 2.8° (azimuth) x 122° (elevation)

Note: A very wide range of sonars are available. This is only identified as an example.

Doppler sonar systems in widespread use

A wide range of Doppler sonars are in use. These typically span a frequency range of 20 kHz to 2 Mhz. Many are fitted to ships for navigational and research purposes. Many are battery powered and moored, or fitted top AUVs etc.

Use: measuring ocean currents



Outstanding Issues:

There is urgent need for objective study of the effects of sound on marine mammals, including

- Masking effects
- Physiological effects due to chronic background noise.
- Potential use of low level sonar devices to learn about the presence of marine mammals, prior to louder transmissions. This could be much more effective than relying on visual detection at the sea surface.